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Tomographic Images Reconstruction Simulation for Defects Detection in Specimen

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***Abstract*—**This paper is the tomographic images reconstruction simulation for defects detection in specimen. The specimen is the thin cylindrical steel contained with low density materials. The defects in material are simulated in three shapes.The specimen image function will be transformed to projection data. Radon transform and its inverse provide the mathematical for reconstructing tomographic images from projection data. The result of the simulation show that the reconstruction images is complete for defect detection.

***Keywords*—**Tomography, Tomography Reconstruction, Radon Transform

I. Introduction

TOMOGRAPHY has been in use as nondestructive testing technique for 60 years. It is a non-invasive imaging technique allowing for the visualization of the internal structures of an object without the superposition of over- and under-lying structures that usually plagues conventional projection images. Tomography refers to the cross-sectional imaging of an object from either transmission or reflection data collected by illuminating the object from many different directions.

It is used to confirm the quality of the product. In particular, to check for defects that can occur in material with the different of size, shape and density.

II. TomographIc Reconstruction

A. Parallel Projections

When X-ray or gamma ray travel through an object they are attenuated and a detector measures the resulting intensity. Different materials have different attenuation coefficients µ.

X-ray attenuation occurs exponentially:

$$I = I_0 e^{-\int \mu(x) ds} \tag{1}$$

Where I_0 is the original intensity, and $\mu(x)$ is the attenuation coefficient at position x along the ray path

B. Radon Transform and Image Reconstruction

The radon transform is widely applicable to tomography, the creation of an image from the scattering data associated to cross-sectional scans of an object. It is the integral transform consisting of the integral of a function over straight lines. The transformed image is often referred to as "sinogram" because every object appears as a sine wave in it.

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III. Simulation

A. Research Methodology

In this simulation, the specimen image will convert to image function in gray scale. Black is zero "0" and white is one "1".The gray scale color is equivalent with the x-ray attenuation of material.

Radon transform will transform the image function to projection data or sinogram. The reconstruction image is created from projection data with inverse radon transform.

B. Geometry

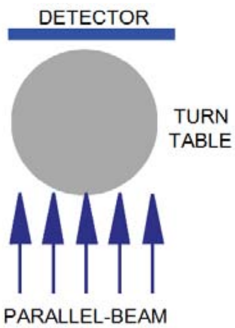

Fig. 1 Tomography Geometry

The tomography system consists of source, an object turntable, and detectors. In this simulation, the beam of source and detectors are parallel. The specimen can rotate 180 degree on the turntable. For the x-ray source, the measured data correspond only approximately to line integral. The attenuation of an x-ray beam is dependent on the energy of each photon and since the x-rays used for imaging normally contain a range of energies the total attenuation is a more complicated sum of the attenuation at each point along the line.

C. Original Specimen

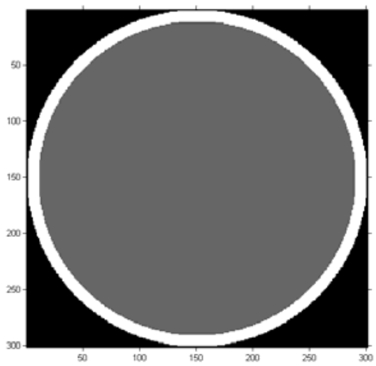

Fig. 2 Image Function of specimen

The specimen function showed in Fig. 2 is 301 x 301 matrix.The black Area outer circle is the attenuation coefficient of the air.

The white circle is the attenuation coefficient of the steel and the inner gray circle is the attenuation coefficient of the material.

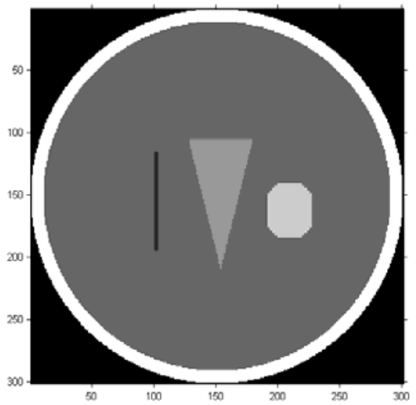

Fig. 3 Function of specimen with defects

Specimen composition consist of the white circle, gray circle and the three simulated defect shapes. The black square is the air.

D.Attenuation coefficients of the simulation

TABLE I
ATTENUATION COEFFICIENTS OF THE SPECIMEN

No.	Properties	Attenuation coefficient
1	Black Square (air)	0
2	White Circle (steel)	1
3	Gray Circle	0.4
4	Black Line (defect)	0.2
5	Gray triangle (defect)	0.6
6	Gray rounded rectangle (defect)	0.8

IV. SIMULATION RESULT

A. Projection Data of the specimen

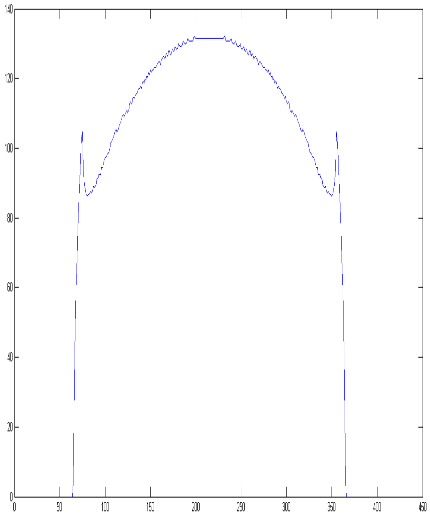

Fig. 4 Projection data in 0 degree

B. Sinogram of the specimen

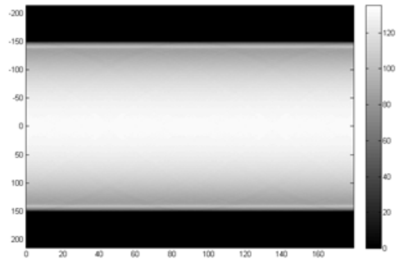

Fig. 5 Sinogram

This sinogram show the smooth image with no defect.

C.Sinogram of the specimen with defects

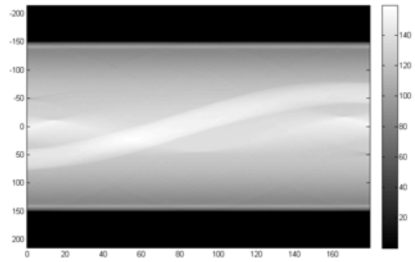

Fig. 6 Sinogram of the specimen with defects

D.Reconstruction Images

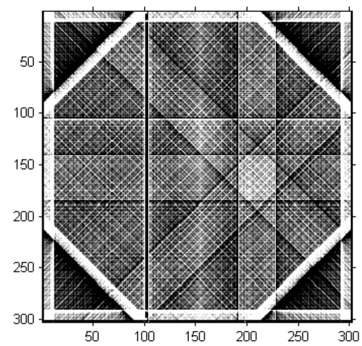

Fig. 7a 45 degree 4 profiles

The four profiles are created to image shows the octagon.

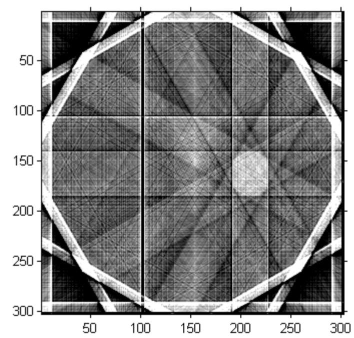

Fig. 7b 30 degree 6 profiles

The six profiles with thirty degree projection data shows the details for the rounded rectangle defect.The shape of the reconstruction image is a dodecagon.

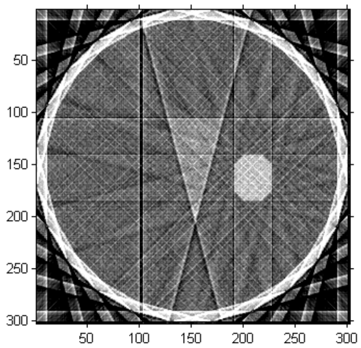

Fig. 7c 15 degree 12 profiles

The third image reconstructed from the 12 profiles with 15 degree in data collection shows a three defects. Especially triangle and rounded rectangle are clearly showed. The line defect can not be determined in a length.The circular shape is clearly similar to the original specimen.

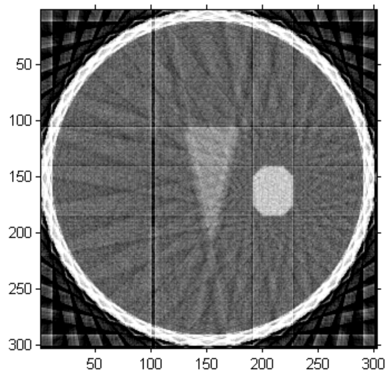

Fig. 7d 10 degree 18 profiles

In the figure 7d shows more clearly in triangle and rounded rectangle defect but it is not clearly in the length of the line defect.

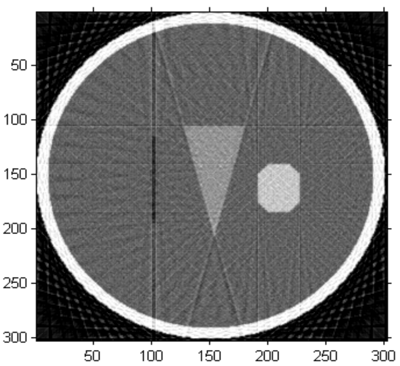

Fig. 7e 5 degree 36 profiles

For the figure 7e, it is the complete image for the defect detection. The length of the black line defect can be measured.

V. CONCLUSION

The simulation result shows the complete reconstruction images. It is very successfully to find the defect in specimen.

Appropriation of the profiles number is "36" (5 degree) to reconstruct the image for detection the defect. For the detection of the triangle or the rounded rectangle can be use only 12 profiles with 15 degree to reconstruct the image.

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